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HENRY A. WALLACE
*Secretary of Agriculture*

HUGH H. BENNETT
*Chief, Soil Conservation Service*

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# GIANT WILD-RYE IN THE CONSERVATION PROGRAM

By LOWELL A. MULLEN [1]

GRASS is man's most powerful ally in soil and moisture conservation. Its part in the scheme of things is fixed but has not as yet been fully developed. Because of certain innate qualities, some species are far superior to others for the given job. The jobs are numerous and varied and, consequently, a diversity of species and/or strains must be used if the conservation program is to reach its fullest development.

Proper plant management, in areas of good soils receiving 18 inches or more of rainfall, is now primarily a matter of additional refinement of practice rather than one of radical revision. Adapted plants and basic facts of practices are known. At present, however, one of the most challenging aspects concerning the use of grass in the conservation program involves the determination of species and proper management of plants especially adapted for use on the millions of acres where climatic and edaphic factors are less favorable for plant establishment but which in spite of this are of inestimable value for range rehabilitation. In many instances merely the establishment of a vegetal cover will serve in attaining the ultimate goal. In any event, the species of plants which can be used will be limited in number, and they must be known to have some very definite qualifications.

*Elymus condensatus* Presl., giant wild-rye, appears to be a very versatile species and consequently merits consideration for this work. This opinion is based on years of experience and notes taken by field men. The plant is so well known and so widely distributed that no general taxonomic discussion is necessary. The Range Plant Handbook, item G52, is an excellent reference for the outstanding characters and values of the species, but it does not discuss the very important matter of variation. Although some variation may be merely a reflection of site factors, there is evidence to indicate that several genetically different forms exist. This is possibly true, to some extent, for many native members of the Hordeae tribe. The species occurs throughout the Pacific Northwest from elevations of 700 feet in central Washington to 7,000 feet in southeastern Oregon. Sites range from Palouse bottomlands and sandy silts to basaltic talus and scablands. It frequently occurs in the dominant vegetation in alkaline flats and is commonly the most abundant grass associated with *Artemisia* on range lands. It is locally abundant along railroad rights-of-way, roadsides, and irrigation ditches. The rainfall varies throughout its range from 8 to 20 inches. No quantitative data are as

**Elymus condensatus** ***in February 1939, near Pullman, Wash.***

[1] Manager, seed and plant collection unit, section of conservation nurseries, Soil Conservation Service, Pullman, Wash.

yet available to show correlation between a given form and geographic distribution in this region. It seems likely that some correlation does exist.

Some common variations are: Height, 3 feet to 6 feet; color, green to bluish; leaves, ¼ inch to ¾ inch in width, rather lax to very stiff, almost glabrous to very scabrous; inflorescence, short and narrow (much like *E. glaucus*) to 10 inches long and ¾ inch in diameter; date of maturity; palatability, poor to excellent. (It is reported but not proved that some strains are more palatable than others.)

WHEN variation in site and plant characters are considered it seems logical to believe that ecological strains or varieties exist which, if properly segregated, might prove of value in conservation practice. Although reports from the field do not indicate the merit of a given plant type, they are most emphatic in stressing the value of the species. The following typical excerpts are taken from field reports and correspondence with ranchers:

". . . impressed by the amount of *Elymus condensatus* used for hay in this area. In some places it brings the same price per ton as *Poa nevadensis* and one rancher informed us that for horses at least it was superior to alfalfa. There appears to be a great deal of variation in this species and several selections have been made." [The area referred to is southeastern Oregon, in the Diamond-Crowley vicinity.]

". . . herd of 50 horses grazing this area did not touch this species (*P. secunda*) but limited their choice to *Elymus condensatus* and *Bromus tectorum*. . . . observations checked by watching the herd for half an hour . . . supports the suggestion of 1937 that *E. condensatus* belongs among the more valuable plants for the south Idaho desert.

"The question of stock grazing *E. condensatus* in Crazy Canyon, Oneida County, was discussed. Mr. ———, who works this area extensively, states that the stock wander back and forth three or four times a year to a distance of 8 miles from a source of water. Their forage is primarily *E. condensatus*, as previously recorded. [Other reports have indicated that stock feeding extensively on this grass can do without other water for considerable periods.]

". . . less harsh form of *E. condensatus* which reaches a height of 6 feet was sampled. . . . This species is ranked as one of the better forage plants for soil locally. In fact, it is in high enough esteem for the agency to make a special project for its selection and sowing on the reservation itself." [Duck Valley Indian Reservation, southwest Idaho and northeast Nevada.]

ONE of the most interesting discussions of giant wild-rye as a valuable range plant was sent in by a rancher in southeastern Oregon. This man and the situation are well known to the author. His comments are based on years of experience as a stockman: "For the better part of my life, I have been running stock (horses, cattle, and sheep) on this eastern Oregon desert. I believe I have had an opportunity to observe the value of grass . . . In the years past I have traveled into every nook and corner of the United States; into Canada and Old Mexico; and have nowhere seen such an abundance of grass and so many varieties as we have on our range here on Steens Mountain.

"Today (August 24) the first band of sheep came into one of our fields. I sat for an hour on a rock observing them as they fed past me, knowing that they always search the range for the best first, which, of course, would be the flowers, 'weeds' as the sheepmen call them, but I also noticed that they never passed up a bunch of the giant wild-rye. I saw as many as six around a single bunch and they did not leave it until the stalks were stripped bare of foliage. Only the heads that they could not reach were left for the deer and horses; and only anise did they seem to prefer to the rye. . . . I recall that at one time, in Barren Valley (Crowley) I was 'out' two head of cows. In the spring I found them, looking good, in a field that had been fed out in the fall; they had wintered in deep snow on the ryegrass stubs. I have seen this happen scores of times. In the early days, the great Harney Valley was the wintering grounds for the vast herds of cattle, and it was principally the ryegrass that wintered them.

"On my horse ranch in Barren Valley, years ago, the principal hay that I put up was ryegrass, to winter what few cattle and horses I had. Others did the same, as the cattlemen there are doing today. And this section is east of Steens Mountain, in the driest part of Oregon. I have seen bands of sheep come off the desert in the winter where they were dying by the hundreds, their skinned carcasses piled in ricks like cordwood, and the dying stopped immediately when they were fed the only available hay—ryegrass. From the standpoint of forage, based on my personal experience and observation, I believe ryegrass to be one of, if not the most valuable, all-around desert grass we have.

"It is a common sight, as one rides through this desert, to see a pile of blow dirt (topsoil) behind a ryegrass clump. A conspicuous example of this can be seen on the Crane-Diamond road . . . On the left of the road, on the slope of a small ridge, is the home of a very aged couple. It is apparent to me that they are a remnant of the 'stickers' who homesteaded most of Harney Valley some thirty years ago. Between their house and the road is a patch of ryegrass that is gaining yearly in elevation from the blow dirt it catches. I have been on this road when the wind was blowing the dust so thick that I was forced to stop the car to await better visibility. Surely this did not occur when old-time Harney Valley waved with ryegrass such as in this old man's field. When these old folks fenced the field there was no more ryegrass in it than there is now across the roadway—here and there a scattered bunch; but year after year the few bunches were allowed to seed, and the field was used for fall and winter pasture.

"And now, ryegrass and moisture conservation. Many times I have ridden around snowdrifts held by patches of ryegrass. When the snow is gone the patch of ryegrass will be perforated with sage-rat and badger holes where at the lower end they have puddled their cistern. As in summer the ryegrass clumps catch the dirt, in winter they catch the snow . . . I notice ryegrass along the streams and gulches, too, buffeting the swirling waters as it clings tenaciously to the banks."

All of these facts and comments prove nothing, but they very strongly indicate that *E. condensatus*, in one or more of its forms, has considerable promise for revegetating areas for which it is adapted. It is not only valuable as a forage and hay plant but also as plant cover to retard erosion and hold snow. It is potentially a heavy seed producer, although frequently the seed is not viable.

The greatest drawback to extensive use of this species is that it is very slow to become established. It is hoped that present observational plantings in this region will provide data for developing better cultural practices and for selecting strains which are superior in speed of establishment, in seed production, and in general utility.

# SIDE-OATS GRAMA FOR EROSION CONTROL

By DONALD R. CORNELIUS [1]

SIDE-OATS GRAMA (*Bouteloua curtipendula*) deserves attention as a grass that will control erosion through central Oklahoma, Kansas, and Nebraska. It is valuable over a somewhat wider area in local situations. It is a native grass which will grow on rough, sloping, or rocky soil and will produce satisfactory forage for grazing purposes.

The distribution of side-oats grama includes 34 States, according to Hitchcock's Manual of Grasses. It has been reported on plains, prairies, and rocky hills from Maine and Ontario to Montana, south to Maryland, Alabama, Texas, Arizona, and southern California. In Kansas it is found in greater abundance through the central one-third of the State. It grows on rocky slopes with shallow soil of low fertility and in competition with other grasses on productive native meadows. A fibrous root system and fairly dense sod make this plant well adapted to holding the soil.

There was remarkable survival of side-oats grama through the droughts of 1934 and 1935. Many pastures observed throughout the eastern half of Kansas show a higher percentage of side-oats grama in relation to total grass plants per unit area than before the severe drought period. Unpublished data obtained by A. E. Aldous of the Kansas Experiment Station on pastures near Manhattan, Kans., show the following percentage of side-oats grama for the years 1927 to 1936.

**Table 1.—*Number* * *of plants per square meter on grazed pastures near Manhattan, Kans.***

| Year | Side-oat grama plants per square meter | Total grass plants per square meter | Percentage of total grass |
|---|---|---|---|
| 1927 | 220 | 1,746 | 12.6 |
| 1928 | 263 | 1,640 | 16.0 |
| 1930 | 262 | 1,380 | 19.0 |
| 1932 | 321 | 1,622 | 19.8 |
| 1935 | 164 | 591 | 27.8 |
| 1936 | 240 | 624 | 38.4 |

* Average of about 70 permanent meter-square quadrants counted each of the 6 years included in the report.

THE PASTURES on which the experiment was conducted were grazed each year. The maximum number of plants of side-oats grama, 321 per square

[1] Junior agronomist, Soil Conservation Service nurseries, Manhattan, Kans.

meter, were found in 1932 following a series of favorable years. A severe drought in 1934 and 1935 reduced the number about 50 percent, but the total grass population was injured to even a greater degree with a reduction of 63 percent from 1932 to 1935.

Recovery of side-oats grama from effects of the drought was more rapid than for the other grasses, showing 46 percent and 6 percent increase, respectively, from 1935 to 1936.

A lack of seed is one of the principal reasons for the limited use of side-oats grama in revegetation work in the Plains section of the United States. Previous to the season of 1937, the only seed harvested in Region 7 was from small areas by hand labor. In August 1937 several hundred acres of meadows and lightly grazed pastures, in the vicinity of Lindsborg and Gypsum, Kans., produced a yield of seed sufficient to justify the use of grass seed strippers. A total of 693 acres of side-oats grama was harvested with an average yield of 32 pounds per acre, making a total of 23,190 pounds.

The season of 1938 was favorable for the production of side-oats grama seed on the native meadows and pastures of the eastern half of Kansas. More or less droughty conditions of the 4 preceding years had reduced the percentage of other species on the native prairie. Side-oats grama had increased in abundance so that at the time of seed production some areas appeared to be pure stands. The previous dry years had favored nitrate accumulation in the soil and with normal rainfall in 1938 conditions were favorable for a good yield of seed. Small combines were available and farmers harvested approximately 50,000 pounds of side-oats grama seed. Yields of 50 to 150 pounds per acre were reported.

WITH present harvesting and cleaning equipment side-oats grama seed usually has a very low percentage of purity when compared with other grass seed. Purity determinations giving the percent by weight of pure seed (the florets containing developed caryopses) in proportion to the total bulk of the material has ranged from 7 to 25 percent for the past 2 years. Inert material composed of empty glumes and florets, the rachis to which the florets are attached, and small pieces of stem or leaf, make up the greatest percentage of the bulk material harvested as seed.

Purity and germination reports for representative side-oats grama seed samples for 1937 and 1938 are given in table 2. The tests were conducted by Katie C. Kirkpatrick, regional seed analyst. There is considerable difference in the percentage of florets containing caryopses as given in the column headed "caryopsis count." The variation of 6.8 percent to 25.14 percent is reflected in the purity of the seed and appears to be one of the most important factors affecting purity. Under the heading "other seed," sand dropseed, *Sporobolus cryptandrus*, has been most common. Germination tests have been consistently low, approximately 25 percent at time of harvest, with an increase during the winter and spring until a germination of 60 to 70 percent is usually reached about planting time in the spring.

ALTHOUGH the purity expressed in percentage of weight is rather low, the number of seeds per pound of side-oats grama is not so much lower than many of our other common grasses. The samples given in table 2 average about 80,000 caryopses or seed per pound of bulk seed. Bromegrass has approximately 137,000 seeds per pound; big bluestem, 48,000 seeds per pound; perennial ryegrass, 223,000 seeds per pound; and meadow fescue, 240,000 seeds per pound.

The type of machinery for harvesting side-oats grama will depend somewhat upon the stand of grass to be harvested. In general, small combines are the most practical and are very satisfactory. Thin stands might be harvested more economically with grass seed

**Table 2.—*Purity and germination of side-oats grama seed from various sources in Kansas, 1937 and 1938***

| Accession number | Year harvested | Source | Caryopsis count | Pure seed | Inert matter | Other seed | Germination: Percentage | Germination: Date | Counts per pound of material | Counts per pound of pure seed | Method of harvesting and cleaning |
|---|---|---|---|---|---|---|---|---|---|---|---|
| KG-457 | 1937 | Bridgeport, Kans. | 15.34 | 15.0 | 84.0 | 1.0 | 22.5<br>63.0 | Oct. 29, 1937<br>Apr. 19, 1938 | 83,009 | 415,047 | Cylinder strippers and fan mill. |
| KG-459 | 1937 | Gypsum, Kans. | 18.60 | 23.50 | 73.25 | 3.25 | 22.0<br>69.5 | Oct. 29, 1937<br>July 11, 1938 | 92,989 | 395,696 | Do. |
| KG-482 | 1937 | Increase plot, S. C. S. Nursery, Manhattan, Kans. | ........ | 21.5 | 78.5 | 0 | 58.5 | Mar. 17, 1938 | 101,833 | 473,646 | Hand-stripped. |
| KG-773-1 | 1938 | .....do. | 18.36 | 18.5 | 81.5 | 0 | 29.5 | Sept. 23, 1938 | 107,503 | 581,102 | Combine. |
| KG-1040 | 1938 | Silver Lake, Kans. | 6.8 | 7.0 | 92.0 | 1.0 | 27.5 | Oct. 10, 1938 | 37,422 | 534,603 | Do. |
| KG-1041 | 1938 | Alma, Kans. | 25.14 | 25.0 | 73.0 | 2.0 | 34.5 | .....do..... | 141,751 | 567,004 | Grain binder and thresher. |

*Typical specimen of side-oats grama; from Lindsborg, Kans.*

strippers, though this depends on the availability of combines and labor. Much of the side-oats grama in Kansas occurs with big bluestem, *Andropogon furcatus*. Combines tend to break the stems of bluestem grass, so that they are difficult to remove. In such instances, it may be better to cut the side-oats grama with a binder and thresh the bundles, when slightly moist with dew, in an ordinary threshing machine.

SEEDLING plants of side-oats grama are not rapid growers as are those of most native species. However, germination of the seed and strength of the seedlings has been very good at the Manhattan nursery. An increase plot of 2.06 acres was planted April 10, 1937, in 30-inch rows, cultivated, and weeded throughout the summer. Seed stalks were produced in August, and 679 pounds of seed were harvested in September 1937. A yield of 335 pounds of cleaned seed per acre was obtained. In 1938 the seed was produced about 3 weeks earlier. The plot was harvested with a combine August 11, 1938, and yielded 780 pounds of seed—378 pounds per acre. Purity tests for the seed harvested in both years are given in table 2.

The spikes composed of 6 to 8 spikelets are not broken up in threshing. This cluster of spikelets is of sufficient compactness to permit drilling through an ordinary grain drill. While the seed is somewhat bulky in this form, weighing about 8 pounds per bushel, it is not so light and feathery as to prevent satisfactory seeding. The rate should be about 20 pounds of seed per acre when the purity is 20 percent. A proportional increase or decrease in rate per acre should be made when the seed has a lower or higher purity test. It responds best to spring planting, in late March or early April, and should be covered to a depth of one-half inch. A firm seedbed, as prepared for alfalfa or other grasses, is desired.

Side-oats grama may be planted alone in central Kansas, but is ordinarily better suited to mixtures. A mixture of side-oats grama, blue grama, and buffalo grass is adapted to western Kansas. Droughty upland soil of eastern Kansas should be seeded with a mixture containing a high percentage of side-oats grama. A good mixture for average conditions in eastern Kansas is as follows: Big bluestem, 45 percent; little bluestem, 25 percent; side-oats grama, 25 percent; and switchgrass 5 percent.

# RIVER BANK PROTECTION

**By GEORGE A. HERION [1]**

TO KEEP the farm land out of the river and the river out of the farm land is the immediate objective of all treatment involving bank protection on the upper Gila River. For the past 40 years many types of treatment have been planned and tried out, with varying degrees of success or failure, to control the meandering, fluctuating charge of this stream. The underlying factors contributing to failure were the absence of generally uniform methods, and the lack of sustained, concerted effort on the part of the landowners.

Prior to 1933 the farmers and ranchers in the Cliff, Gila, Duncan, Virden, and Safford valleys waged an unsuccessful war against the ravages of the rampant Gila. For the most part they worked independently, with little or no aid from a public or governmental agency. And then with the advent of the Soil Erosion Service of the Department of Interior, now the Soil Conservation Service of the Department of Agriculture, an agency was established which was to take an active part and interest in the problem. This agency supplied the necessary sustained and concerted drive which was needed. Cooperating with interested landowners, the Service tackled the problem immediately.

[1] Assistant forester, Soil Conservation Service, Santa Fe, N. Mex.

FROM THE START it was known that complete and absolute control could not be accomplished within reasonable cost limitations. In those early days it was believed also that steel and concrete were the only effective materials which would successfully combat and remain to combat the river. Later, revegetation of the channel banks was admitted into the picture. Revegetation, with a minimum of structural, mechanical protection, is the generally accepted solution today.

Observational evaluations of previous work and results were made, and these led to the elimination of widespread channel clearing, of river straightening by the construction of long pilot channels and of the widespread use of rail and rock revetments. Lengthy, heavily constructed rock jetties, earthen dikes, and driven pile and rock-filled piers were also discarded. The evolution from heavy, bulky construction to a

more streamlined and lighter type of structure brought lowered construction costs and, at the same time, more effective protection.

Structural protection is designed specifically to give immediate, short-time support to both the stream bank and to plantings. In addition to protection of plantings, many structures are designed to facilitate and ensure the future of the revegetation phase by preparing the planting site through silt deposition. Often mechanical protection is unnecessary to the establishment of plantings; but in other instances plantings cannot be undertaken without it.

THREE MAJOR TYPES of structural protection are now used on the Gila. The rail tetrahedron type is used most frequently and under a greater variety of conditions than either of the other two. For this type of treatment, costs range from \$1.50 to \$2.25 per lineal foot of bank protected. Specifications call for 50- to 70-pound railroad rail, with members 7½ or 10 feet in length. Tetrahedrons are placed in a continuous line between the stream and cut bank, so that stresses developed by stream flow against the line may be properly and evenly distributed along the line.

On curved cut banks, where this type is generally used, the line is placed in the form of a catenary, to distribute the force more uniformly. Two 1-inch steel cables run the entire length of the tetrahedron line, with one of the cables running through the apex of and clamped to each tetrahedron, and the other running parallel to the base of the line and likewise clamped to each structure. The upstream and downstream ends of each cable are securely and independently tied to substantially anchored deadmen. Such deadmen are usually set well back on the bank. Where the tetrahedron strings comprise a length greater than 250 feet, additional line anchors are needed. These should consist of three 15-foot, 50-pound rails driven into the streambed with 1 foot projecting above the surface, and with one rail at each of the three base vertices of the anchor tetrahedron securely fastened to the tetrahedron with clamp and cable. The line anchors are spaced at intervals of 125 to 250 feet, depending on the curvature of the line, and at critical locations with respect to stream flow.

TREE AND CABLE deflectors are placed at the line anchors extending from the tetrahedron line to the bank. This "groin" or deflector consists of overlapping trees and cable clamped to the tetrahedron and anchored to a rail driven into the bank. Deflectors of this type serve a twofold purpose. They cause deposition of silt between the line of tetrahedrons and the bank by decreasing the velocity of water flowing through and behind the tetrahedrons, and they function as a jetty which forces the water back to the channel.

Tetrahedrons are used on the most critical locations, often where the channel flow is directed at the cut bank and the banks have an overhang or sheer wall of 5 to 20 feet above the level of the channel bottom. They are well adapted to locations where quicksand makes a pile-driven structure impossible. In "quicky" or on soft-bottom, brush mats have been used to prevent sinking of the structure and misalinement of the entire string.

The driver rail and tree type of protection is used extensively on less critical areas where severity and degree of cut bank and the flow action of the river are favorable for lighter, less costly type of treatment. Cost per lineal foot of bank protected with this type of structure varies from \$0.90 to \$1.50. This bank protection consists of 20-foot, 50-pound rails driven down about 15 feet, with 5 feet projecting above the surface and set at 16-foot intervals along a line parallel to the cut bank in a position similar to that described for tetrahedrons. A single, 1-inch cable runs the entire length, and is attached to each rail by means of cable clamps; the cable ends are anchored to deadmen. A double line of overlapping trees is placed on the inside of and parallel to the line of rails. The lines are secured to each other and to the driven rail by means of short cable and clamps, in such a fashion as to permit the trees to rise and fall vertically without moving the rails. At intervals of 125 to 250 feet, log and cable groins or deflectors, similar to those used with tetrahedrons, are placed at a 30° angle with the direction of stream flow.

TREE AND CABLE revetment constitutes the other means of structural bank protection now employed quite generally on low-cut banks, or on straight sections of the river where the cutting action is not so intense or severe. This type of protection is definitely limited to the less critical areas where large trees are plentiful. Entire trees are placed about 6 to 8 feet apart, depending upon crown spread, along the bank with the butts on top of the bank and the branches extending into the water. The trees are placed at an angle of 30° downstream. Two lines of 1-inch cable are run the full length of the protected bank and are anchored on both ends to deadmen; the

*Vertical planting method employed behind tetrahedron string. Planted March 1938; photograph made May 1938. Debris on face of tetrahedron lodged by floods. Recorded silt deposition behind line 3 feet.*

trees are secured to the main cable by small ½-inch cable and 1-inch clamps. Where the supply of tree-size willows is plentiful, the use of this species for this type of mechanical protection has distinct advantages in that new sprouts originate from the branches when silt has been deposited on them.

It has been found advisable to defer planting behind mechanical protection until silt accumulations and deposits have been built up between the outer edge of the protection and the cut banks. In many instances it has been necessary to wait a full year before planting. Floods are seasonal, usually occurring in the winter and early spring. As the planting season is limited to a 3-month period—January, February, and March—the planting program behind such structures is limited to mechanical work completed during the preceding year. Where plantings are made as the only means of bank protection, it is unnecessary to wait for silt accumulations, as these plantings are made only on the cut bank.

TREE AND SHRUB FORMS of willow have proved to be the most effective plants for bank protection and stream channel stabilization. Due to the various and individual growth characteristics of the several species, selection of a particular one is based upon the job requirements of the problem present.

A tree willow, *Salix gooddingii*, is used on locations where the vegetation must furnish future mechanical protection in addition to the protection offered to the soil by the fibrous root system. The small, bush-type willow (several species, including *Salix exigua* and *Salix irrorata*) is used on the less critical sections of low-cut banks where mechanical obstruction to the flood waters is not desired, and where water must pass over them rapidly with a minimum of debris accumulation.

In bank protection planting, cuttings are preferred to nursery-grown or native rooted stock, as procurement, handling and planting costs are considerably lower. In addiiton, cuttings have two decided utility advantages in that they will afford some immediate partial mechanical protection and resistance to flood action, and they may be planted on more adverse sites and under conditions unfavorable for rooted plants. Comparative results as to the effectiveness and survival of either indicate no appreciable difference.

Cuttings are procured locally from native stock adjacent to the planting sites. Two classes of cuttings are made—the large, post-size class ranging from 4 to 16 feet in length and 1 to 9 inches in diameter; and the smaller size slip cuttings of 1 to 3 feet in length and one-half to 1½ inches in diameter.

THERE ARE THREE generally accepted planting methods employed; the vertical, horizontal, and the angular or stream-bank. Of the three, the vertical method is best adapted to a greater range of site variables and, therefore, is most frequently used. Under high-cut banks the vertical method is used entirely, as the cuttings planted in this manner are able to withstand bank sloughing. Large willow posts have been planted to depths of 16 feet, although this is an exception to the general rule which is from 4 to 8 feet in depth. Lack of moisture or excessive amounts, and poorly aerated soils, limit the use of vertical plantings. Cuttings planted in this manner must be inserted to live water, or to depths where the soil will remain permanently moist.

The requirements of the individual job establish the limits to which cuttings are permitted to extend above the ground. Where additional silting is to be expected, as in cases where plantings are made on silt beds deposited behind tetrahedrons, the posts are set to heights which allow for or will compensate for expected future depositions. In other instances where silting has reached the expected maximum, cuttings are set deep with a projection of 1 foot or less above the surface. The use of high cuttings (over 4 feet in height) has been generally discontinued, as they are wasteful of material and costly to cut, handle, and plant. To avoid livestock browsing, they have been planted to extend 8 feet above the surface. Fence construction, where possible, more than offsets the additional costs involved in handling poles of this size.

HORIZONTAL PLANTINGS are made on poorly aerated soils where moisture is close to the surface. This method of planting is limited to those wet, boggy areas that are formed between the line of mechanical protection and the cut bank. Cuttings are laid in shallow trenches 2 or 3 inches deep, and all but the upper side of the wood is covered with earth. Quite often it has been found necessary to anchor or tie them together to prevent them from washing away.

Where the site is favorable, horizontal plantings are usually made in jetty form extending from the cut bank to the outer edge of the protection, and in lines paralleling the mechanical structure. Sprouting takes place along the entire length of the material planted, and after two growing seasons becomes sufficiently established to grow independently of the parent stock. Although limited by site requirements, this method has been utilized with success where other methods have failed. Its low cost favors more general usage.

On less critical straightaway sections of the river that do not require mechanical protection, vegetative covering is quickly and easily established by the angular or stream-bank method of planting. It is often necessary to give the banks a 1:1 slope; the cuttings are laid in shallow trenches extending up the bank, with butts imbedded in muck or sand of the stream to a depth of 2 feet or more. The cuttings are partially covered with soil; this permits that the upper surface be alternatingly exposed and lightly covered. Where necessary, the cuttings have been anchored with No. 9 wire tied to driven stakes, or quite often tied to vertical cuttings planted at the toe of the slope. Plantings are spaced at intervals of 4 feet and effect a riprap appearance along the treated area. This type of planting forms a solid vegetative mat from the edge of the river to the top of the bank.

Bank protection and channel-control measures will not in themselves effect permanent protection for the adjacent farm lands unless they are constantly maintained and renewed. The ephemeral nature and character of the Gila River, the cutting and filling action, and the fluctuating flow all tend to create unforeseen conditions and problems which can only be met as the particular situation arises. Prolonged drought on the watershed, heavy snows, unprecedented seasonal rains, and simultaneous flooding of its tributaries offer daily and seasonal problems which affect the entire course of the river and the irrigated valleys dependent upon it. Plans made today are of necessity changed tomorrow.

Realization must come that continuous farming in the upper Gila Valley, under conditions contrary to most natural laws and tendencies, is an extremely hazardous occupation, and permanent control of the river and protection of the land can only be accomplished by a continued and lasting struggle against the forces of nature.

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### Pasture Management for Dairy Stock

Planning pasture management for small dairy herds is a difficult problem in most areas and the final solution for many of them is yet to be determined. United States Department of Agriculture Technical Bulletin No. 660, The Hohenheim System in the Management of Permanent Pastures for Dairy Cattle, issued October 1938, reviews and reports on one system adapted to intensively farmed areas. It may not be the answer to all questions but it is a fine contribution and the contents should be read by everyone interested in permanent pasture management.

*—Liter E. Spence.*

157080—39——2

*A stand of blue grama, obtained by stocking the range to grazing capacity of the forage.*

# STOCKMAN'S RECORDS REFLECT PROPER LAND USE

**By HERSHEL M. BELL [1]**

AGRICULTURAL WORKERS can learn much from progressive stockmen who have recognized the advantages of proper land use. Information gathered from such sources can be extremely useful in planning operations and in encouraging a spread of conservation practices.

Last spring (1938) I had the privilege of inspecting a ranch in west Texas at the end of a 12-months grazing season, just before new growth started. There was an excellent stand of grass, with only a few invading weeds, and grass seed stalks could be seen in abundance. This year, in February, I again visited this ranch and, although the land had been grazed for 7 months, the pasture appeared almost untouched by livestock. When I interviewed the operator he told me that he had records of his operations, and these records he generously opened for review.

In the first place, he had changed his rate of stocking from 36 head per section (640 acres) to 24 head per section, beginning with 1935. He did this by adding 10.5 sections of land to his ranch, thus indirectly reducing the rate of stocking. The forage on the ranch is composed chiefly of blue grama, black grama, and curly mesquite grass. The following tabulations were compiled from his records:

| | *Before 1935* | *After 1935* |
|---|---|---|
| Size of ranch ... acres | 14,080 | 20,800 |
| Rate of stocking ... head per section | 36 | 24 |
| Animal units grazed | 792 | 792 |
| Pasturage per animal unit, year long ... acres | 18 | 27 |
| Ratio of bulls to cows | 1 : 25 | 1 : 25 |
| Calf crop ... percent | 0.65 | 0.93 |
| Weight of calves at sale time ... pounds | 350 to 375 | 425 to 450 |
| Average yearly expenditure for cottonseed cake | $1,050 | $520 |

[1] Acting regional range examiner, Soil Conservation Service, Fort Worth, Tex.

THE RANCH LAND is valued at $75,000; buildings at $7,500; livestock at $34,000. Operating expenses have remained approximately the same, but income has increased steadily since the change in rate of stocking.

| Year | Gross income | Net income |
|---|---|---|
| 1930 | | $5,000 |
| 1931 | | 1,900 |
| 1932 | | 769 |
| 1933 | $5,494.75 | 1,500 |
| 1934 | 12,159.00 | [1] —4,000 |
| 1935 | 11,647.68 | 2,800 |
| 1936 | 12,721.71 | 3,700 |
| 1937 | 17,011.52 | 5,000 |
| 1938 | 20,420.00 | [2] 6,500 |

[1] Cattle sold under Government drought-relief agreement.
[2] Estimate.

THIS IMMEDIATE financial gain, resulting from range conservation practices, is fully recognized, but the more enduring result from such practices is in the protection and perpetuation of the rancher's investment in the land. On this ranch, accelerated erosion has been reduced if not stopped entirely. By diverting water out of drainages which were forming gullies, and spreading it over broad, flat swales he has made native haylands of from 400 to 600 acres which were formerly only fair to good grazing lands. More than half this area could be cut for hay as a reserve feed supply. This ranch unit is only one of many examples, both in practice and research, of the soundness and practicability of the principles of range conservation.

In the conservation of our grazing lands it is particularly important that the utilization of increased forage, produced as a result of conservation practices, be predicated first upon the effect it has on reduction of soil and water losses. If immediate increases in quality and quantity of forage are evaluated in terms of forage alone the beneficial effects will be short-lived and little or no change will be noted in erosion and water waste.

The Soil Conservation Service has stressed the need for range conservation. The policies under which it operates emphasize consideration of the entire farm or ranch unit in the plan; not only must the soil and water be conserved, but a balanced, practical and economically sound farm or ranch business must be established. In such a program it is believed that a fundamental principle which places priority on the reduction of soil and water losses and less importance on an immediate increase in forage, permits the accomplishment of both, but assures greater stability of the latter.

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# CONTOUR CULTIVATION STUDIES WITH THE RAIN SIMULATOR

By H. L. BORST and RUSSELL WOODBURN [1]

*Four inches of rain per hour on contoured corn.*

WHAT HAPPENS when contour cultivation furrows fill and overflow during a heavy rain? The virtue of contour cultivation as a soil conserving measure is generally well appreciated. Tests of the practice at the various Soil Conservation experiment stations and by workers elsewhere have shown its value. Although the value of the practice for average rainfall is well established, there is a question as to what actually happens when the ridges are overtopped and cut through by run-off from intense rainfall. In such cases, is the soil loss less or, perhaps, more than it would have been from a field cultivated with slope? The opinion is current that in heavy storms the accumulated water in the furrows, augmented by rainfall, surges through breaks in the ridges and causes greatly accelerated erosion.

During the progress of experiments with an artificial rainfall apparatus at the Zanesville Soil Conservation Experiment Station, a somewhat preliminary study was made to evaluate the effect of contour cultivation on soil and water losses and, possibly, to answer the questions just mentioned.

## Three Plots

THREE PLOTS were installed in the spring of 1938 on a 15-percent slope of Muskingum silt loam soil. The plots were 72.6 feet long by 6 feet wide, or one one-hundredth acre in area, and were planted to corn. The rows of corn on one plot were planted up and down the slope. On the other two plots, the rows were on the contour. The corn plants were about 16 inches apart in the row. Soybeans were planted between the corn plants on one of the contoured plots. The plots were cultivated by hand during the summer and in so doing, the contoured rows were ridged to a height of 3½ to 4 inches above the slope line or a vertical height of about 2½ inches. Rain simulator tests were made on the plots late in the season. Although at this time the corn was still green, the soybeans had ripened and some of their smaller roots had decayed. The contour ridges had become quite firm and were reinforced to some extent by root growth.

Two series of runs were made on the noncontoured plot; one series after it was cultivated level, and then a series after it had been furrowed up and down the hill. The tops of the ridges of the contoured plots were carefully leveled before the tests were made in order to make both plots comparable. These plots were cultivated crosswise before the tests and an earth seal was made between the ends of the ridges and the plot side metal.

As the plots were 6 feet wide, the condition tested was practically similar to that in an ordinary contoured field with dams placed in the furrows every 6 feet. Since the ridges were truly on the contour, well compacted and free from weak points, the experiment

[1] The authors are project supervisor and associate agricultural engineer, respectively, at the Soil Conservation Service Experiment Station, Zanesville, Ohio. The article is a contribution from the Division of Research of the Service and the Ohio Agricultural Experiment Station, Ohio State University.

(plainly "loaded" in favor of contour cultivation) measured ideal contour cultivation or "contour cultivation at its best," rather than a field condition wherein it is practically impossible, with ordinary farm machinery, to lay out contour rows that are absolutely level.

### Three "Rains"

AFTER THE RAINFALL APPARATUS was assembled over a plot, three different "rains" were applied. The first two were each 1 inch of rainfall at 4 inches per hour, and the third, 2.70 inches at 8.75 inches per hour. In each case, the run-off from the plot was conducted to a tank for measurement and sampling. There was little delay between runs, and therefore it should be understood that the plots received 4.70 inches almost as one rain. Four inches per hour for 15 minutes represents a 6-year frequency rain for the station, and 8.75 inches per hour for 18½ minutes is in excess of the so-called 100-year frequency. There is, therefore, little question as to the unusual and highly destructive rainfall applied to the plots.

The soil and water losses recorded are shown in table 1.

### Water Losses

IT WAS of considerable interest during the runs to note the large amount of water which the soil of the contoured plots was literally forced to take in—this because of the ponding above the ridges; it was particularly noticeable during the first runs. Run-off started from the noncontoured plot within 3 minutes after "rain" was applied, and the total water loss was nearly 50 percent. On the contoured plot with corn only, about three-fourths of an inch of "rain" was applied before run-off started, and the inch of rainfall produced only 8 percent run-off. The first inch of rain on the contoured corn and soybean plot produced no run-off. All of this rain was stored in the furrows and the apparent effective infiltration rate was therefore equal to the rain intensity. Run-off was also significantly reduced from both of the contoured plots during the two subsequent runs.

### Soil Losses

THE SOIL LOSS was very low from all contoured plot runs. The losses from the contoured plots for the 8.75-inch per hour rainfall amounted to only about one-ninth of that from the corn cultivated with the slope.

The reason for the low soil losses from contoured corn (in spite of considerable run-off from the 8.75-inches per hour intensity) was apparent during and after the run. Pools of nearly quiescent water formed in the furrow above each ridge. These pools were, in effect, sedimentation basins. The velocity of the run-off water entering these pools was so much reduced that much of the suspended soil in the run-off dropped out. As the ridges were cut through by the overflowing water, the depth of these small detention basins was gradually lowered until only a small depth of water was left in the furrow. Even after the furrow ceased to act as a detention basin, a comparatively flat section in the plot gradient remained. The velocity of run-off continued to be low across this flat reach, and deposition continued. The efficiency of this sedimentation system was evidenced by terraces or deltas of considerable size in the depression below each ridge. It is particularly significant that deposition continued after the ridges were cut through, and there was little tendency toward accelerated erosion from the water stored in the furrows.

(Continued on p. 16)

**Table 1.—*Comparison of soil and water losses from noncontoured and contoured corn plots***

| Run No. | Rainfall | | | Plot 1—Noncontoured corn | | | Plot 2—Contoured corn | | | Plot 3—Contoured corn, soybeans | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Intensity | Duration | Amount | Run-off | Infiltration | Soil loss | Run-off | Infiltration | Soil loss | Run-off | Infiltration | Soil loss |
| | *Inches per hour* | *Minutes* | *Inches* | *Percent* | *Inches* | *Tons per acre* | *Percent* | *Inches* | *Tons per acre* | *Percent* | *Inches* | *Tons per acre* |
| PLOT 1—CULTIVATED FLAT | | | | | | | | | | | | |
| 1 | 4.00 | 15 | 1.00 | 52.1 | 0.48 | 5.20 | ........ | ........ | ........ | ........ | ........ | ........ |
| 2 | 4.00 | 15 | 1.00 | 88.5 | .11 | 8.46 | ........ | ........ | ........ | ........ | ........ | ........ |
| PLOT 1—CULTIVATED WITH FURROWS UP AND DOWN SLOPE | | | | | | | | | | | | |
| 3 | 4.00 | 15 | 1.00 | 47.8 | 0.52 | 5.60 | 8.0 | 0.92 | 0.36 | 0 | 1.00 | 0 |
| 4 | 4.00 | 15 | 1.00 | 88.9 | .11 | 7.45 | 48.7 | .51 | .48 | 46.4 | .54 | 1.00 |
| 5 | 8.75 | 18.5 | 2.70 | 95.0 | .14 | 26.4 | 78.4 | .59 | 2.85 | 68.0 | .86 | 3.05 |

# *The Growth of Liming*

**By Paul Bissell**[1]

FOR THE past several years, the Soil Conservation Service and the Civilian Conservation Corps have worked together in demonstrating to farmers, and to the public in general, methods and practices for relieving or entirely eliminating land ills through the intelligent use of means either at hand or readily available. The many accomplishments of this type of cooperative work can be seen on every side throughout the country. Often little more was needed than to emphasize an existing condition and to point out through demonstration an easily adaptable remedy that had been at least partially overlooked. Liming, as a soil-conditioning practice for erosion control and with its attendant increased crop yields, is an example of such a cooperative demonstration by the Soil Conservation Service, the C. C. C., and the farmer.

For many generations farmers have added lime to the soil, knowing that in general their crops would be improved. The practice, however, was confined primarily to the "sweetening" of sour or acid soils. To many farmers the term "liming" suggests only those neutralizing effects obtained when the alkaline action of lime comes in contact with the acids in the soils. Other beneficial effects of liming often are not considered, and this is unfortunate.

Although it is true that the neutralizing or sweetening of acid soils is one great virtue of liming, this is not the only benefit or perhaps the most important one to be obtained from the use of lime. Were the other benefits fully appreciated by all farmers there is little question but that liming would be an even more universal practice than it is.

Soil acidity is the result of either of two major conditions. In soils comparatively free of organic matter, it is caused by the presence of compounds of an acid nature derived from silicates which constituted a large part of the rock from which these soils were formed. In other soils, it is caused by the decay of organic matter which is present to some extent in all soils. In either case, under natural conditions certain processes ordinarily tend to prevent these acids from accumulating to any injurious extent. When they do accumulate to excess, however, acid or sour soil is the result.

Acid soils do not produce maximum yields for most crops, and liming is a specific remedy for this condition. Extremely acid soils are not as prevalent as is often supposed and, furthermore, it is absolutely essential that organic decomposition be encouraged in soils even at the risk of increasing acidity, for it is largely through this decomposition process that crops can grow. In fact, by the use of fertilizer, manure and cover crops, farmers must constantly add organic matter to the soil, solely for the benefits to the soil from decomposition of these materials.

*Enrollees at work clearing a field of an outcropping of limestone. The limestone was burned and used for liming the field.*

And so it is that the farmer faces a greatly complicated problem. Organic decomposition is essential for the growing of crops, and he must encourage it to the extent of supplying material for it if he is to expect increased crop yield; and yet he knows that this very process will produce acids which, if they are present in excess, will tend to cut down the increase he is striving for. Happily for the farmer, liming offers him a solution. Lime added to soils in such instances acts in a dual role. It stimulates the much desired decomposition process and thus creates a soil condition most favorable to growing crops and, at the same time, by its acid-neutralizing action it prevents the accumulation of acid in excess. Now, since only a small proportion of soils are really sour (and only "sour" soils are referred to when the value of "sweetening" quality of liming is discussed), it is obvious that liming, as the term is generally understood, benefits only a minor portion of the soils of the country. On the other hand, the stimulation of organic decay is beneficial and really essential to both sweet and sour soils, all soils; and since liming offers this stimulation, it can

[1] C. C. C. information, Soil Conservation Service, Washington, D. C.

be concluded that this is the more important of the two benefits.

In some soils, liming seems to offer the further advantage of furnishing calcium directly to the plant. All plants need calcium to build up their tissues. All soils contain some calcium, and in the past it has been generally assumed that all soils contained enough of this element for plant growth. But we know that in some soils this calcium is in a form only slightly soluble and is not readily available to plant life. It has been proved, by experiment, that the addition of lime to such soils increases crop yields. Lime is calcium in oxide or carbonate form, and it is more soil soluble than the calcium silicates which already exist in the soils mentioned. It appears, therefore, either that such soils are deficient in soluble calcium and that this need is supplied directly to the plant by the lime, or that the lime causes some other reaction, beneficial to plant life, in the soil itself. Probably both are true to some extent. Certainly, the lime (calcium) is free and available to the plant; and it is generally accepted that lime makes soluble and available for plant food other minerals, such as phosphorus and potash, contained in the soil.

Lime also affects the physical characteristics of some soils. In heavy soils, which contain large proportions of clay or silt, the fine soil particles often become associated so closely that free circulation of air and water is prevented, and this is unfavorable to plant growth. If these fine particles can be made to gather in large groups, however, each group behaving as one large particle, the soil particles are then said to have "flocculated," and the soil has a crumb structure. Farmers know that a crumbly condition in this type of soil is most desirable. Liming has been found to assist materially the flocculation of heavy soils.

Though these many benefits to the soil through liming are all known to farmers, nevertheless the need for lime in the soils never has been adequately met—and this in spite of the fact that lime in various natural forms such as limestone, marl, marble, coral and oyster shells is readily available to most farmers. Indeed, it was estimated in 1933 that the annual lime requirement of American farms was 24 times the amount sold by commercial concerns in that year—the year in which the Soil Conservation Service was founded.

Since its beginning the Service has recognized the need for more lime in the soil, and has consistently advocated liming as an approved practice. The result has been an increased demand for agricultural lime from commercial companies. There has also been a heartening response from farmers themselves, in quarrying local limestone deposits and liming their fields with the quarried rock, after it was either crushed or burned.

Perhaps in no section has this advocated practice of liming been more generally accepted than in West Virginia. The farmers in this State needed only the help and direction of technical experts to encourage them in using this gift of nature in the form of limestone outcroppings.

These outcroppings were, of course, not always on the surface; in many instances they are visible now only as a result of erosion caused by forest destruction and overgrazing. Since a land underlain by soluble limestone offers difficult problems in soil erosion control, it might easily be argued that this limestone is not wholly a blessing. Nevertheless, these outcroppings will furnish lime in abundance, and lime is essential in revegetating many partially eroded areas existing today.

With this practical viewpoint regarding the liming problem the Soil Conservation Service extended advice and aid to West Virginia farmers who had signed cooperative agreements with the Government. Many of the farmers had overgrazed pasture lands or fields which, under the agreements, were to be retired to permanent pasture. The pastures needed to be revegetated with erosion-resistant grasses. Outcroppings of limestone were tested for the richness of their calcium content. Then, C. C. C. enrollees, under the direction of Soil Conservation Service technicians, were put to work quarrying the rock. Sometimes these outcroppings were large and, when centrally located, they furnished rock for several cooperators. Sometimes the work was done on the individual farm. Where rock crushers were available, or where through other Federal, State, or county agencies they could be obtained, the rock was crushed and used in pulverized form. In some sections of the State, however, particularly where fuel was available at low cost, burning rather than pulverizing was the procedure more generally used.

Though the burning of limestone to obtain rock lime has been practiced for generations, when the Service began its program in West Virginia there was a dearth of available men experienced in this work, just as there was little technical data on kiln or stack construction. Faced with the necessities of the situation, the regional and project engineers, the technical staffs at the camps, and the C. C. C. enrollees themselves cooperated in evolving plans for a standard kiln and stack for use throughout this region.

Blueprints of the completed plans were then made available to the farmers throughout the entire State.

As the work progressed, slight improvements were made from time to time in both design and methods. The suggestions came not only from the engineers and superintendents but in some instances from the enrollees themselves.

Often the limestone was burned at a central location, so that it was possible to furnish rock lime to many cooperators from the one kiln. In such an instance, a special detail of C. C. C. enrollees was assigned to this kiln, which was kept burning continuously for many months. In other areas the cooperators were encouraged to build stacks, with the help of C. C. C. labor, so that the limestone could be burned for farm use. Whether the process was pulverizing or burning, however, virtually all the liming materials made available by the Soil Conservation Service were obtained through the C. C. C. enrollee labor. These materials could then be used only on eroded lands, or lands subject to erosion, for the establishment or improvement of erosion-resisting vegetation upon such lands. The lands must be within project or work areas, and the owners of such lands must have signed cooperative agreements with the Soil Conservation Service.

Primary consideration was given to lands devoted to permanent pasture, hay, and orchards. Secondary consideration was given the croplands where legume-grass mixtures were incorporated for two or more successive years in rotation. Furthermore, while encouraging farmers to use lime, the amount of liming materials furnished by the Government was kept at a minimum, and in no case was it allowed to exceed one-third of the aggregate amount called for in the cooperative agreement. It was not the policy of the Government to make delivery of liming materials to the farmers; and also, care was exercised, in the processing of lime, to grind or burn only an amount sufficient to meet the definite terms of the cooperative agreement and to set up demonstrations to show to farmers the benefits of a liming program. After observing the demonstration the farmer could secure sufficient lime, either by processing or purchase, to treat the remaining portions of his farm.

While the Service furnished liming materials only to farms within project or work areas, nevertheless the demonstrations of liming on cooperators' farms aroused the interest of many farmers outside these areas, and there was a demand for blueprints of the standard stack and kiln. More than 500 of these were furnished from one project, in response to personal requests by land owners, and the result is that many farmers are obtaining rock lime by burning limestone from their own outcroppings in their own stacks or kilns.

*Soil Conservation Service cooperator liming pasture. Here the spreader is being filled.*

In the camp and project areas, more than 11,000 tons of lime have been burned by the C. C. C. enrollees, and 64,000 tons have been crushed. These figures are encouraging; yet the actual tonnage of lime used in the fields is of secondary importance as compared with the indisputable fact that, by cooperative demonstration, the Soil Conservation Service and the C. C. C. have aroused the farmer to the full benefits to be obtained by liming and have pointed out the ways and means for gaining these desired benefits. With this impetus there seems every reason to expect that the practice of liming will increase steadily, with benefits to the soil, to farmers, and to the lime industries throughout the Nation.

## RAIN SIMULATOR

*(Continued from p. 13)*

Under field conditions, the picture would be quite different from the ideal situation which obtained during these tests. The ridges would be low during the early part of the season and would be loose and easily damaged when first thrown up by cultivation. Rows would frequently be off-contour, and lateral flow would result. Concentration of run-off would take place at depressions and weak spots. Although the experimental conditions were not the same as true field conditions, nevertheless a valuable lesson was presented.

The effect of lowering the velocity of run-off, even momentarily, was shown to be very important in reducing both soil and water losses. The nearly quiet or slowly moving water above the ridge was extremely effective in causing the run-off to drop its load. The necessity of adhering to true contour as nearly as possible is emphasized, as the true contour tends to spread run-off over a long stretch of ridge and minimizes concentration. Since a certain amount of contour divergence may be inevitable in any field, the need is indicated for a device which will place dams in the furrows at short intervals.

*(Continued on p. 20)*

# *Revegetative and Gully-Control Experiments in the Red Plains Region*

**By H. M. Elwell, J. W. Slosser, and Harley A. Daniel**

According to recent information (6), the abandonment of cultivated land has gradually increased in this region during recent years. Reports (1) also show that over 1,359,000 acres of Oklahoma soil have been retired from crop production. Because of the rapid destruction of this great agricultural country, the State Experiment Station obtained an area of submarginal land in 1932 on which, in cooperation with the Soil Conservation Experiment Station, several valuable studies were introduced.

Since Vernon soil is a predominating series of the Red Plains region and erodes easily (3, 5), revegetative and gully control studies were investigated on a typical area. The various experiments occupied about 70 acres of land which had been abandoned for crop production. There were many gullies ranging from 5 to 12 feet deep. An erosion survey shows that about 12 inches of the surface soil was removed during a period of about 37 years of continuous cultivation.

Under virgin conditions, this soil was underlain by sand, stone, and shale at a depth ranging from 2 to 4 feet, with occasional surface outcrops. The native soil was rather high in organic matter and the rate of infiltration fairly high. This dark surface layer varied from 6 to 18 inches in depth and was very erodible under cultivation. Once this surface soil is removed by erosion, the remaining subsoil has very little fertility, a low infiltration rate, and a restricted reservoir for the storage of water. Consequently, run-off and soil losses are extremely heavy. Conclusive evidence of this may be obtained from a study of the data recorded from the controlled plots at the Guthrie Station (2 and 5). The percentage of run-off from the artificially eroded Vernon soil was about double, and the soil loss was 1.5 times greater than that of an adjacent cultivated surface area of the same size. Both areas are farmed to continuous cotton, with rows up and down the slope.

The land when placed under observation in 1932 had a sparse vegetative growth of annual and perennial grass. The degree of erosion and one of the gullies may be seen in photograph No. 1. An attempt was made to divert the run-off from the original channels by construction of small cheap contour ridges between and above the source of the gullies. These small terraces were built with one or two rounds, with a horse-drawn long-wing plow. Wherever possible, these structures were drained into areas of grassland. The method used was conducted very economically, so that the cost of construction did not exceed the value of the land.

Gully control work was conducted principally with temporary structures made of native material. They were designed to catch soil on which vegetation could be established. Brush and pole dams of different types were built at various places, their life being an average of about 2 years or less. Burrowing animals and rodents have caused many failures because this type of structure is a natural harbor, although the usefulness of such dams may be increased if vegetation is established just above the site shortly after construction is completed. Usually, considerable soil is removed from the banks and floor of the channel in placing the material used for making dams. During this operation, if this soil is placed above the dam it provides a place where sods of native grasses, such as Indian, *Paspalum floridanum*, and little and big bluestem, may be set. The best results have been obtained when a small amount of soil, taken from the area where the sod was removed, was carefully placed around the vegetative plantings.

Other dams, such as Bermuda sod bags and small loose rock, were tried, but with little success. Attempts were made to establish trees and vines on the fills above these dams, but the eroded material that washed into them was very infertile and the shallow soil caused a high mortality rate of these plantings.

The most satisfactory results were obtained from legume plantings in gullies on eroded areas, especially biennial sweetclover which received applications of 100 pounds of lime and 50 pounds of superphosphate per acre. The second year's growth of sweetclover in a gully with such fertilizer treatments is shown in photograph No. 2. This seed was planted broadcast at a rate of 15 pounds per acre. Temporary check dams of stalk were prepared, and the sides of some of the gullies were plowed down to approximately 1:1 slope before the area was planted. *Lespedeza sericea*

Note.—The authors are assistant soil conservationist, associate agricultural engineer, and project supervisor, Soil Conservation Experiment Station, Guthrie, Okla. They wish to express their appreciation to Horace J. Harper for assisting with the sweetclover studies, to B. F. Kiltz for furnishing grass seed, and to H. G. Lewis and others for making the experiments possible.—Editor.

*1. One of the gullies on the East Farm of the Soil Conservation Experiment Station at Guthrie, Okla., in 1932 before any experiments were started.*

*2. The second year's growth of sweetclover that received 100 pounds of lime and 50 pounds of superphosphate per acre. These plants are growing in the same gully as shown in figure 2, after the banks were cultivated to about 1:1 slope.*

*3. A good protective cover of native climax grass on Vernon soil that has been out of cultivation for about 25 years. This is a result of natural reseeding under favorable environmental conditions.*

has made a good growth, without fertilization, in gullies and on eroded plots at several locations on the station. Experimental tests on eroded areas with little and big hopclover, yellow trefoil, southern and manganese bur clover, Korean lespedeza, vetch, and kudzu, were failures even when fertilizer and lime were applied.

Other fertilizer experiments with sweetclover were conducted on adjacent badly eroded Vernon fine sandy loam in 1935. The results obtained from three series, consisting of 5 plots each, on treated and untreated areas, are as follows:

| Plot | Treatment | Pounds per acre of fertilizer [1] | Yield [2] of dry sweetclover per acre | | |
|---|---|---|---|---|---|
| | | | A [3] | B [4] | C [3] |
| | | | *Pounds* | *Pounds* | *Pounds* |
| 1 (check) | No treatment | ........ | 665 | 105 | 670 |
| 2 | Superphosphate | 40 | 1,395 | 270 | 1,025 |
| 3 | Rock phosphate | 40 | 2,255 | 165 | 1,750 |
| 4 | Superphosphate and limestone. | 40<br>80 | 1,975 | 555 | 1,605 |
| 5 | Rock phosphate and limestone. | 40<br>80 | 2,240 | 590 | 2,060 |

[1] All applications of phosphate and limestone were made in the drill row at the time of planting, under the seed.
[2] Yields from second-year growth, planted at the rate of 2½ pounds of seed per acre in rows 3 feet apart.
[3] Planted in shallow listed furrows.
[4] Planted in smooth seedbed.

. These data show that light applications of phosphate and lime increased the yield of sweetclover three to four times. Studies of similar treatments on other soils in Oklahoma were reported by Harper (4). In this report he states that "the application of fertilizer in the drill row with sweetclover seed indicates that the rock phosphate is more effective in increasing the yield of sweetclover than equal amounts of superphosphate applied under similar conditions." Although this area was seeded to native grasses following the experiment, the volunteer sweetclover produced

a nice growth last year. These results also indicate that badly eroded land may be made to produce enough forage for limited grazing, and increase the organic matter content of the soil. The latter seems to be necessary before seeding or sod plantings of the native climax grasses will produce much growth or cover.

Several studies have been made with seed plantings of the following grasses on well-prepared seedbeds: *Andropogon scoparius, Andropogon tener, Andropogon saccharoides, Andropogon furcatus, Bouteloua gracilis, Panicum obtusum, Panicum virgatum, Triodia flava, Sporobolus airoides, Sorghastrum nutans, Cynodon dactylon, Buchloë dactyloides, Paspalum dilatatum*, and *Agropyron smithii*. The *Bouteloua gracilis* and *Sporobolus airoides* made a fair ground cover the first year after seeding. All of the *Andropogons* made a very poor ground cover even after the third year of growth. These grasses, especially *Andropogon scoparius* and *furcatus*, seem to require a higher condition of fertility than the other two *Andropogons* and the *Bouteloua gracilis* or the *Sporobolus airoides*. Low available nitrogen and the poor physical condition of the eroded Vernon soil of the region appear to be two of the limiting factors in obtaining a profitable growth of the climax grasses.

The punishment that native anticlimax grasses will stand and their low nutrient requirements for survival may be observed in many localities. The erosion-resistant capacity of these grasses is an important factor in the process of establishing vegetative cover. Observations made at this stage of the revegetative process indicated that the roots and turf form small areas that are practically impervious to erosion. As the soil continues to weather and the vegetation to decompose, there is a tendency for a surface accumulation of residue and lichens. Through these slow-forming agencies, more favorable conditions are created for plant development. The addition of this organic matter offers an opportunity for better infiltration of moisture, and as a result, more seedings are started. This process of securing an erosion-resistant cover is slow, even under favorable environmental conditions.

According to the best information available, an area of adjacent land, pictured in photograph No. 3, has been out of cultivation about 25 years. No conservation methods were practiced, and there has been very little grazing. The erosion problems appear to be about solved on this particular site, and the vegetation ready for some utilization. Such information shows that a considerable period of years is required under natural plant succession, to change the nutrients and physical condition of Vernon soil so that it will support a protective cover of climax grasses.

Results obtained at this station indicate that the time required by nature for the establishment of such grasses may be reduced through the use of economic conservation practices and the introduction of legumes.

## Summary

The State Experiment Station, realizing the importance of conserving soil, obtained an area of eroded, abandoned Vernon soil near Guthrie, Okla., in 1932. In cooperation with the Soil Conservation Service, about 70 acres of this land were immediately occupied by several revegetative and gully control experiments.

The gully control work was conducted principally with temporary structures made of native material. Brush and pole dams of different types were built at various places, the life of which has been an average of 2 years, or less. The usefulness of such dams may be increased if vegetation is established just above the site shortly after construction is completed. Other structures such as Bermuda grass sod bags and small loose rock, were tried out with little success. Attempts were made to establish trees and vines on the fills above the dams, but the eroded, infertile, shallow soil caused a high mortality rate of these plantings.

The most satisfactory results have been obtained from the setting of clumps of native grass, such as Indian, little and big bluestem, and *Paspalum floridanum*, and the seeding of perennial sweetclover and *Lespedeza sericea* in gullies after temporary check dams of stalk were prepared and the banks plowed down to approximately 1:1 slope. The best growth of sweetclover was obtained where the soil was fertilized with 100 pounds of lime and 50 pounds of superphosphate per acre.

Observations have shown that a considerable period of years is required under natural plant succession to change the nutrient and physical conditions of Vernon soil so that it will support an erosion-resistant cover of climax grasses.

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*(Continued on p. 20)*

# BOOK REVIEWS AND ABSTRACTS

by Phoebe O'Neall Faris

## THE NORTH AMERICAN ASSAULT ON THE CANADIAN FOREST. By A. R. M. Lower, W. A. Carrothers, and S. A. Saunders. Toronto, New Haven, and London. 1938.

As the work of our Service takes definite form throughout the United States and broadens in scope and idea, a study such as this, which treats the continent as a whole, assumes significance to the reader who likes to keep one step ahead of forestry trends as related to the conservation of natural resources. Certainly, it behooves us to know what has happened and is happening to the immense forest lands to the north of us and the role we, the great consumer Nation, have played and are playing in changing the widely varied tree map between the oceans—and the soil map with it. As for maps, read the book with the erosion map of the United States propped up in front of you; you will wish that it extended northward to include the Canadian regions of timber supply.

The extensive volume was compiled, to use the first author's own words, for . . . "the promotion of sympathetic cooperation in attacking our common North American problems and of understanding our common environment." It is, in reality, complementary to other volumes of a series on the relations of Canada and the United States.

Professor Lower's share of the book, the first 223 pages, is a geographical and historical study of lumbering in eastern Canada in relation to the American demand markets, and is presented from the standpoint of the regions involved in forest exploitation on the continent since those early days when white men began "lumbering" their way westward: First, the great forests of New York State, then into southern Ontario, through the Michigan, Wisconsin, and Minnesota hardwoods and conifers, northwestward to the banks of the Saskatchewan, and onward to California and British Columbia—the ever-growing army of lumbermen following the way of the trees to supply increasing demand. Here is found a most thorough and interesting analysis of continental river systems, early forest cutting and land changes and migrations, with the development of the canal and the railroad in a long-sustained attack on forest areas ranging over a territory as vast as that of Europe. The chapter on supply forests is especially illuminating in its delineation of range of white, red, and Banksian pine, the black, white, and red spruce, balsam fir, hemlock, the tamarack, and the white cedar. The white and red pines receive rather extensive treatment as to commercial importance, extent of present stands, environment, and effect of exploitation. Two chapters on woods operations, river driving, and sawmills give an outline history of the development of present-day lumbering operations.

The remainder of Professor Lower's portion of the volume presents an extensive study of lumbering for export in Canada, from early days of West Indies trade before the Revolutionary War when American forests were considered "inexhaustible." The reader is guided through periods of vicissitudes and change, into the era of the Reciprocity Treaty and the rise of American competition for Canadian raw materials, and then on to the present and the new trade agreement between the two countries. The old "forest buccaneer" days are gone forever from the eastern part of the United States where rapacious exploitation started more than two centuries ago. The Canadian Appalachian region, the Canadian Shield (Laurentian Plateau), and the northern (Canadian) Cordilleran area are shown to be the regions of continental forest supply today. Indirectly, Professor Lower's final chapter is a plea for careful thought and planning regarding the continental forest problem. With reforestation going forward in the United States, cannot the great Canadian stands still in existence be conserved as permanent supply?

The second author, Professor Carrothers, writes over a hundred pages on forest types, forest tenure, lumber trade and markets, and the shingle and pulp and paper industries of British Columbia. A great volume of data is included to show the far-flung extent of these related industries. It is a straight-forward statistical presentation, with no indication that sustained-yield methods are being used in the British Columbia forests.

S. A. Saunders, in the final 20 pages of the book, treats the forest industries of the Maritime Provinces—New Brunswick, Nova Scotia, and Prince Edward Island. And here there is an indication that conservation methods will be applied in the near future for the sake of the economic structure of the region.

The significant thing about this exhaustive economic and historical study is that it emphasizes a middle continental story, little realized, in which Canadian-American relations have had profound effect upon the exploitation of a great continental resource—the trees. We may study migration and exploitation in the United States "by way of the grass" without crossing the Canadian border; but when it comes to the forests, the story of their growth and extent, their death at the hands of man, and the economic implications of their rotting stumps goes back and forth and far to the north and far to the south of any political borderline.

The authors have included extensive bibliographies; a geographical-historical index; diagrams showing forest products in Canadian-American trade; and maps showing range of red and white pine, centers of lumber production of eastern Canada, forest reserves, and forest districts in British Columbia. In addition, an excellent inside-cover map, in color, shows the four great geographical regions of the continent, extending into the Arctic Zone, with the tree zones superimposed.

## RAIN SIMULATOR

*(Continued from p. 16)*

Some question as to the agronomic feasibility of this type of cultivation may be raised. Flat cultivation has been in vogue for some time. Even in Ohio, however, water may be a limiting factor in crop production, and it would seem that the saving of water by contour cultivation would offset any possible bad effect of ridging so that increased yields would result. The acre yields of corn from the plots used in the test were 9 bushels on the noncontoured plot and 15 and 18 bushels on the contoured plots. There was an indication, at least, of increased yield from the contoured plots.

Cultivation ridges similar to those on the contoured plots are entirely feasible if the proper implement is used.

## EXPERIMENTS IN RED PLAINS

*(Continued from p. 19)*


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